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ORIGINAL RESEARCH

THE RELATIONSHIP BETWEEN CORE ENDURANCE AND BACK DYSFUNCTION IN COLLEGIATE MALE ATHLETES WITH AND WITHOUT NONSPECIFIC LOW BACK PAIN

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ABSTRACT

Background: Physical activity and sports can be associated with low back pain. However, little is known about the relationship between core stability and nonspecific low back pain (LBP) among athletes.

Purpose: The purpose of this study was to investigate the relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific LBP.

Methods: Fifty-five male collegiate athletes from a variety of sports were recruited for this study. Their mean age was 21.50 ± (2.54) years, mean weight was 70.96 ± (5.33) kg., and mean height was 174.38 ± (4.37) cm. Thirty athletes with non-specific LBP and twenty five healthy athletes were assessed using McGill's anterior, posterior, and left and right plank core endurance tests (seconds) and for dysfunction using the Micheli functional scale (MFS). Pearson's product moment correlations examined the relationships between core endurance and MFS.

Results: There were significant differences regarding the measured core endurance tests between the healthy athletes group and the nonspecific LBP group ($p < 0.05$). Additionally, good negative ($r = -0.794$) and moderate negative ($r = -0.541$) correlations were found between MFS and trunk extensor and flexor endurance tests, respectively in the group with nonspecific LBP.

Conclusion: The results of this study imply that poor core endurance is likely associated with nonspecific LBP in collegiate athletes. Injury risk reduction and back management programs for the athletic population should include strategies that emphasize endurance of the core muscles especially the trunk extensors and flexors.

Level of Evidence: **2b**

Keywords: collegiate athletes, low back pain, trunk endurance

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INTRODUCTION

Exceptional performance during sport is considered the ultimate goal of all training programs specifically designed for athletes. This goal can be achieved effectively through specific exercises that target the strength and endurance of the core musculature.[1] The core plays an important role in stabilizing the peripheral joints and reducing the risk for injury especially during high levels of physical activity.[2] Moreover, core stability has been proven to promote efficient body mechanics, allowing the athlete to maximize force production while minimizing loads placed on proximal joints. This is especially important during complex movements, such as: running, jumping, swimming, throwing, and hitting a volleyball.[3,4]

Core musculature includes the abdominals anteriorly, the paraspinals and gluteals posteriorly, the diaphragm superiorly, and the pelvic floor and hip girdle musculature inferiorly.[5,6] In trained athletes, the core musculature is activated through a feed-forward mechanism shortly before movements of the upper and lower extremities to act as a foundation upon which skilled movements can be performed.[7] Positive relations have been reported between core stability training and athletic performance using measures such as agility time, vertical jump height, kicking performance, and throwing accuracy.[8,9]

Low back pain (LBP) accounts for 30% of the musculoskeletal complaints occurring among the athletic population.[10] Despite this high incidence, the etiology of chronic nonspecific LBP is not clearly understood, which increases the difficulty in developing effective treatment programs.[4] LBP is considered one of the most common reasons for missing playing time in competitive athletes.[11] The relationship between LBP and physical activity has been shown to be curvilinear in adolescents, considering that extremely low and high values of physical activity are associated with an increased risk of back pain.[12]

Poor trunk control during athletic activities is proposed to be a contributing factor to nonspecific LBP. It has been reported that recurrent nonspecific LBP is associated with altered motor coordination[13] and increased fatigability of the trunk muscles.[14] Hence, the faulty movement patterns characterized by early dominant activation of trunk muscles and delayed activation of synergistic muscles can cause instability and excessive joint motion with increased risks for dysfunction and pain.[15]

Individuals with nonspecific LBP have also been shown to exhibit decreased whole-body balance and lumbar position sense compared to asymptomatic individuals.[16-18] Core stability interventions have been demonstrated to be effective in changing spinal muscle recruitment patterns as measured by electromyography in individuals with nonspecific LBP.[19] There is lack of research on the correlation between core endurance and nonspecific LBP dysfunction. Therefore, the purpose of this study was to investigate the relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific LBP.

METHODS

Participants

Fifty-five male collegiate athletes were recruited for this study. Several team sports were represented in this sample, including soccer, basketball, handball, and volleyball. Thirty athletes with nonspecific LBP were recruited from the college sports injuries clinic. This study group was matched with twenty-five healthy athletes, as control group. Table 1 presents the demographic data of participants.

Collegiate athletes with nonspecific LBP who had pain for more than three months with positive prone instability test were eligible.[20] The prone instability test has a sensitivity of 0.72 and is used to identify individuals who demonstrate lumbar segmental instability with poor muscular control, a common deficit that is associated with non specific LBP.[13] Exclusion criteria included refusal to participate in the study, LBP as a result of a specific spinal disease, infection, presence of a tumor, osteoporosis, fracture, structural deformity, inflammatory disorder, radicular symptoms, or cauda equina syndrome.[21] The study was authorized by the Ethics and Research Committee of the Batterjaa Medical College. All participants signed a written informed consent and agreed with the study in advance.

Recruitment took place in two steps: First, a sports injury specialist, with Ph.D degree in orthopedic and

Table 1. *Demographic data of participants**		
	Athletes with LBP, *n*=30	**Athletes without LBP, *n*=25**
Age, years	21.05 ± 2.59	22.06 ± 2.42
Weight, kg	70.60 ± 4.85	71.40 ± 5.94
Height, cm	173.33 ± 4.41	175.64 ± 4.06
*Note: no statistically significant differences existed between groups.		

sports physical therapy, identified the potentially eligible athletes with nonspecific LBP and referred them to the university biomechanics lab. Second, the researcher conducted a screening for inclusion and exclusion criteria in order to make the final decision regarding eligibility to participate in the study. Once included, the prone instability test was performed, with the athlete laying prone with the body on the examining table and legs over the edge and feet resting on the floor with the trunk muscles are relaxed. The examiner applied posterior to anterior pressure to an individual spinous process of the lumbar spine and any provocation of pain was reported. Then the patient lifted the legs off the floor and posterior to anterior compression was applied again to the lumbar spine while the trunk musculature was contracted. The test was considered positive if pain was present in the resting position but subsided in the second position, suggesting that the muscle activation is capable of stabilizing the spinal segment.[20] Twenty-five collegiate athletes without LBP volunteered to participate in the study, as the control group. All participants were provided with oral and written information about the study.

Procedures

All testing was performed in a single session in a controlled research laboratory. The same investigators measured the same tasks throughout the study. The following were the standard measures used for both groups:

Micheli Functional Scale (MFS): The MFS is a 5-item questionnaire consisting of a symptom question, three activity-related questions (extension, flexion, and jumping), and Visual Analogue Scale (VAS). The questionnaire is designed to assess symptoms of back pain and ease or difficulty during performance of various sporting activities relative to low back pain. Responses from the symptom questionnaire are scored from 0 to 5 points while the total score for the three activity questions is scored from 0 to 10 points (extension, 0-4; flexion, 0-3; jumping, 0-3). The visual analog scale is scored from zero (no pain at all) to ten (worst pain) based on a 10-cm line. Overall score is determined by adding the questionnaire responses to the VAS score. This maximum score possible is twenty-five. This number is then multiplied by 4 in order to result in a range of final scores from 0 to 100. A score of 0 is optimal and indicates the least amount of dysfunction, while a score of one hundred indicates maximal dysfunction. The MFS is a valid and reliable instrument for assessing pain and functional levels in the young athletes between 12 to 22 years.[22]

McGill's core endurance tests: McGill's tests were used to examine participants' core endurance. These tests consisted of four positions: the trunk anterior flexor test, the right and left lateral plank, and trunk posterior extensor test.[23] Participants performed one practice trial that lasted a few seconds to confirm correct positioning and then one test trial was recorded per position where the maximum time (seconds) participants could maintain a static position was measured. The same investigator visually determined the end of all tests to assure reliability of testing. This investigator used the commands 'start' and 'stop' to initiate and conclude the test while an assistant investigator recorded the times using a stopwatch. During the trunk posterior extensor test the assistant held straps to stabilize the lower body and the investigator determined the start and end of the test. The order of the four test positions was randomly assigned.

During the trunk anterior flexor test, participants sat with the trunk flexed to sixty degree with their hands across their chest and both knees flexed to ninety degree. Trunk and knee flexion were both determined using an electronic goniometer. Time was initiated when the participants assumed the measured position (Figure 1A), and stopped when the trunk deviated forward or backward from the 60° angle.

For the left lateral musculature plank test, participants' feet were placed one on top of the other, the right arm was perpendicular to the floor, elbow resting on the mat, with the left arm across the chest and the left hand on the right shoulder (Figure 1B). A similar position was utilized for the right lateral musculature plank test, with the left arm perpendicular to the floor (Figure 1C). Time was stopped when the investigator visually determined that the line between the participants' trunk or lower body segments (thigh or shank) was not maintained.

For the trunk posterior extensor test, participants laid prone on an examination table with both ASIS's on the edge of the table with their hands on the seat of a chair placed in front of them at the edge of the table. An assistant held the lower extremities above and below participants' knees in order to secure the lower body (Figure 1D). Time was started when participants assumed a horizontal position of the trunk, removed their hands from the chair and then crossed them across their chest, and time was stopped when participants were unable to remain in that position.

Statistical Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) for Windows version 16.0. (SPSS, Inc., Chicago, Illinois). As a prerequisite for parametric calculations for the analysis of difference analysis of relationship measures, data were screened for normality assumptions. Multivariant analysis of variance (MANOVA) test was used to analyze the difference between the healthy and nonspecific LBP groups. Then, Pearson's product moment correlations were used to examine relationships between core endurance and back dysfunction level. An apriori alpha level of 0.05 was used

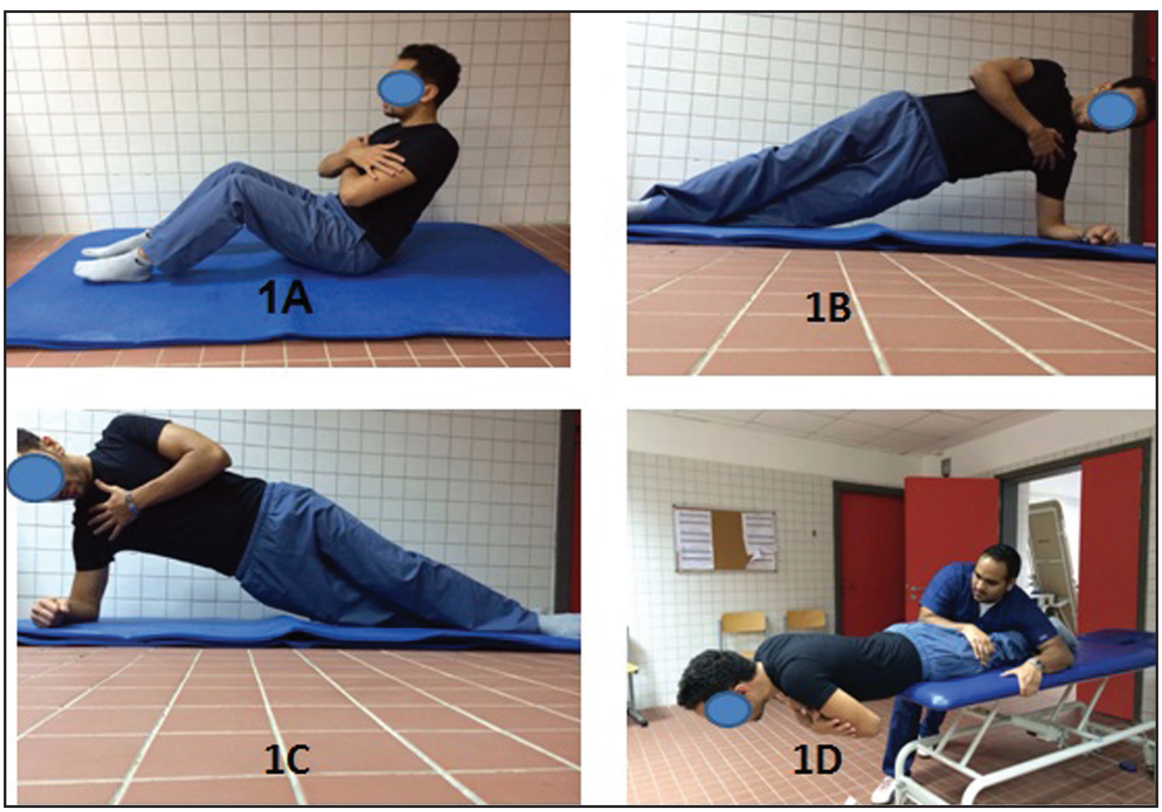

Figure 1. *Core Endurance tests of McGill. A. Flexor endurance test, B. Left side plank, C. Right side plank, D. Extensor endurance test, note therapist stabilization of the lower body.*

for all tests. The strength of the relationships was described as detailed by Portney and Watkins, where 0.00-0.25 indicated little or no relationship; 0.26-0.50 indicated fair degree of relationship; 0.51-0.75 indicated moderate to good relationship, and 0.76-1.00 indicated good to excellent relationship.[24]

RESULTS

There was no significant difference between the groups in age, weight, and height ($p = 0.144$, 0.584, 0.051) respectively, as shown in Table 1. The result of the MANOVA test showed significant differences regarding the measured core endurance tests between the healthy group and the nonspecific LBP group ($p < 0.05$). The athletes with nonspecific LBP group had significantly lower endurance test values when compared with the healthy control group.

Additionally, The MFS scores were statistically higher for the collegiate athletes with nonspecific LBP than those who had no LBP ($p < 0.05$). Outcomes are presented in Table 2. The relationship between MFS scores and each McGill's core endurance test for nonspecific LBP and normal healthy groups was calculated using Pearson correlation coefficient. No relationship was found between MFS scores and all McGill's core endurance test in the group without LBP. Good negative ($r = -0.79$) and moderate negative ($r = -0.54$) correlations were found between MFS and trunk extensor and flexor endurance tests, respectively, in the group with nonspecific LBP, as shown in Table 3.

DISCUSSION

The purpose of the present study was to test core muscular endurance in collegiate male athletes with and without nonspecific LBP and to correlate the results with their functional status as it is scored using MFS. According to the results of this study, the athletes in the LBP group showed significantly lower as compared to the group without LBP for core muscular endurance in the four tested directions. These findings should

Table 2. *McGill's core endurance test values and MFS scores of participants.*

		Athletes with LBP, *n*=30	Athletes without LBP, *n*=25
Core endurance test (seconds)	Trunk flexor	43.76 ± 13.03	57.63±6.25
	Trunk extensor	34.06 ± 9.44	63.20±11.57
	Right lateral plank	28.74 ± 8.13	42.09±7.43
	Left lateral plank	23.84 ± 7.05	33.90±8.16
MFS		46.98 ± 5.52	2.64 ± 3.40

MFS= Micheli Functional Scale, *Significant at p < 0.05

Table 3. *Correlation (r) between MFS and core endurance tests of athletes with and without nonspecific LBP.*

		Athletes with LBP (r)	Athletes without LBP (r)
MFS	Trunk flexor	-0.54*	-0.13
	Trunk extensor	-0.79*	-0.17
	Right lateral plank	-0.27	-0.07
	Left lateral plank	-0.20	-0.04

LBP= Low back pain, MFS= Micheli Functional Scale, Significant at p < 0.05

provide health care professionals with further into trunk muscle performance in college aged athletes, which could be integrated with the already existing injury prevention program and rehabilitation protocols for lumbar related athletic injuries. Many of these injuries may be attributed to muscular deficiencies, such as weakness[25] and poor endurance.[26]

Preparticipation physical examinations are often performed as a major component of injury risk reduction screens in order to identify potential risk factors. Several activities have been identified as potential screening tools, as standard procedure to quantify trunk muscular endurance do not exist.[27,28] In 1999, McGill et al[23] advocated the use of McGill's core endurance tests to evaluate the trunk musculature stamina especially in patients with LBP. Normative published data for the isometric endurance of the trunk flexors and extensors using the anterior and posterior (Sorensen) tests in novice athletes with mean age 21 years are 136, and 161seconds, respectively. The mean endurance time for the right and left lateral plank are 95, and 99 seconds.[29] Of note, the recorded scores for McGill's core endurance tests in all directions in the subjects in the current study were markedly low for both groups as compared with the international normative data

The results of the present study are in accordance with the findings of Sung,[14] who reported increased lumbar musculature fatigability in patients with recurrent LBP, and with those of Da Silva et al[30] who concluded that individuals with nonspecific LBP presented with significantly more pronounced lumbar musculature fatigue via electromyography than people without nonspecific LBP in both younger and older adults. Moreover, the findings of Correia et al.[31] showed that symptomatic tennis players with nonspecific LBP demonstrated lower activation of extensor muscles (erector spinae and longissimus thoracis), less co-contraction patterns and less abdominal musculature endurance when compared with the asymptomatic healthy players.

Additionally, the current study demonstrated that lower times of McGill's endurance test in the anterior and posterior directions correlated with higher scores on the MFS, indicating more difficulty in performing athletic activities and higher pain in those with poorer trunk endurance. The MFS was chosen to assess pain and dysfunction in this study because it is a back-specific rating scale for athletes at the collegiate sports levels.[22] It has been suggested that athletes with poor trunk muscular endurance may easily injure passive, pain-sensitive structures of the lumbar spine, which ultimately affects physical performance.[32] Also, early loss of core control secondary to fatigue may lead to aberrant or excessive intervertebral translation and rotational motion. Normal values for these osteokinematic movements have been reported to be three to four millimeters translation between L1 and S1 in the sagittal plane, seven to thirteen degrees for rotation in L1-L5 segments and 14-20 degrees in L5-S1.[33] Local core muscles play an essential role in maintaining segmental stability and controlling intervertebral motion. Kong et al.[34] reported that impairment of the function of these local muscles in individuals with chronic nonspecific LBP can change the extent of segmental vertebral motion.

During physical activities, the trunk musculature provides both mobility and stability to the lumbopelvic region. Changes in trunk muscle activity in the form of weakness or insufficient motor control, typically observed in individuals with LBP may lead to increased dysfunction and suboptimal athletic performance.[35] Ambegaonkar et al.[29] reported that core musculature endurance test values did not influence Star Excursion Balance Test (SEBT) scores. Their results can be attributed to the muscular activation patterns of the knee, and various other leg muscles during this specific functional test.[36]

Laird et al[37] and Bystrom et al[38] concluded that core stability exercises are more effective in reducing pain and disability in the short, intermediate, and long term compared to no treatment, regular medical treatment, education, or general exercise in patients with nonspecific LBP. A good negative correlation was found between lumbar musculature endurance and functional disability in the current study, which can be attributed to the poor scores recorded specifically in the posterior direction that were markedly lower than those recorded in the control group and the anterior direction of the same group. This demonstrated a clear imbalance between the trunk flexors and extensors when compared with the values reported in other studies.[29,39] No correlations were found between right or left side endurance tests and MFS score. This was most likely due to the nature of the activities of daily living listed in the questionnaire, which focused on pain associated with lumbar flexion, extension, and jumping, without including rotational or change of direction activities that requires the action of the oblique musculature.

There are some limitations of this study. First, this study was delimited to male collegiate athletes, thus limiting the generalizability of the results. Second, while McGill's tests in four directions were used to assess the endurance of the prime movers of the core, other local stabilizers may have contributed to the outcomes on McGill's tests (e.g. shoulder muscles to support the body during a plank position). Another limitation is the lack of correlating levels of the MFS scores to levels of sports disability as minimal, moderate, and severe. Further studies should identify the levels of sports disability with the MFS and relate this factor to core endurance. Such information may be helpful in the clinical decision-making surrounding return to competitive sports. Finally, more studies are needed to examine the effect of core stability training on trunk endurance in those with nonspecific LBP.

CONCLUSION

The results of this study demonstrated that collegiate athletes with nonspecific LBP had significantly lower trunk musculature endurance test values than healthy athletes. Good and moderate negative correlations were found between scores on the MFS and trunk extensor and flexor endurance tests, respectively. Therefore, the rehabilitation program of athletic population with nonspecific LBP should include strategies that emphasize endurance of the trunk extensors and flexors.

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